AN IN-VITRO STUDY COMPARING DENTINAL DEFECTS INDUCED BY DIFFERENT NITI ROTARY FILE SYSTEMS DURING ROOT CANAL PREPARATION.

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ABSTRACT

Aim & Objective- The aim of this in vitro study was to evaluate and compare the dentinal defects caused during root canal preparation using hand K files, rotary Mtwo files, and rotary K3XF files. **Methodology-** Sixty extracted, intact, non-carious human mandibular premolars were decoronated to a standardized root length of 12 mm and randomly divided into four groups (n = 15 each). Group 1 served as the control group with unprepared canals, while Groups 2, 3, and 4 underwent root canal preparation using hand K files (step-back method), rotary Mtwo files (crown-down method), and rotary K3XF files (crown-down method), respectively. During preparation, 5% sodium hypochlorite was used as an irrigant, 17% EDTA gel as a lubricant, and final rinsing was performed with saline and distilled water. All specimens were stored in distilled water until sectioning. Horizontal sections were obtained at 3 mm and 6 mm from the root apex using a hard tissue microtome under water cooling, and the sections were evaluated under a stereomicroscope at 45x magnification for dentinal defects. **Results-**The incidence of dentinal defects followed the order: Group 1 < Groups 2, 3, 4, with Group 2 and Group 3 showing similar results, and Group 3 exhibiting fewer defects than Group 4. The types of defects were distributed as follows: Group 2: Craze lines > Fractures and Partial cracks. Group 3: Fractures > Partial cracks > Craze lines. Group 4: Fractures > Partial cracks and Craze lines. **Conclusion-** These findings highlight the influence of instrumentation techniques and file design on the type and incidence of dentinal defects during root canal preparation

Keywords- Mtwo, K3XF, Dentinal defects, Fracture, Partial cracks, Craze lines.

INTRODUCTION

Root canal treatment is a cornerstone of modern endodontic therapy, aiming to eliminate infection and preserve the natural tooth structure. The success of this procedure depends significantly on effective cleaning and shaping of the root canal system, a process that often employs nickel-titanium (NiTi) rotary file systems due to their superior flexibility, cutting efficiency, and ability to conform to complex canal anatomies. However, despite their advantages, these systems can inadvertently induce dentinal defects, including microcracks and fractures, which may compromise the long-term prognosis of the treated tooth.[1-3]

Dentinal defects have garnered increasing attention in endodontic research, as they are potential precursors to vertical root fractures, one of the most unfavorable complications in endodontics. The extent to which different NiTi rotary systems contribute to these defects varies due to differences in their design, metallurgy, and motion kinematics. Understanding these variations is crucial for clinicians to make informed choices in their practice and to optimize patient outcomes.[4-7]

This study aims to compare the dentinal defects caused during root canal preparation with hand files and two different Ni-Ti rotary files systems. It seeks to identify the file system that causes the least

dentinal defects during the procedure and to evaluate and compare the various types of dentinal defects observed in the root canal.

MATERIAL AND METHODOLOGY

Sixty human single-rooted mandibular premolars indicated for extraction due to poor periodontal prognosis or orthodontic reasons were collected. The collection, storage, sterilization, and handling of the extracted teeth were conducted following the guidelines and recommendations of the Occupational Safety and Health Administration (OSHA) and the Centers for Disease Control and Prevention (CDC).

To remove all soft tissues, the teeth were immersed in a 5% sodium hypochlorite solution for ten minutes. Calculus was mechanically removed from the root surfaces using ultrasonic scalers. Subsequently, the teeth were stored in fresh distilled water until further procedures. Radiographs were taken in buccolingual and mesiodistal projections to exclude teeth with double canal morphology, resorptions, or obstructions. Each specimen was examined under a stereomicroscope at 20x magnification (Magnus MSZ Bi) to exclude those with external defects.

Inclusion criteria: Teeth with a single root canal and intact apices were selected. **Exclusion criteria:** Teeth with severe curvatures, apical resorptions, calcifications, or fractures were excluded.

Each specimen was decoronated using a diamond disc (3M) under water cooling to achieve a standardized root length of 12 mm. The root surfaces were flattened to standardize the canal length, ensure straight-line access, and provide a reference plane. Each specimen was then coated with polyvinyl siloxane elastomeric impression material (GC-Exaflex) and embedded in an acrylic resin block made from self-cure acrylic resin (DPI). The samples were stored in distilled water until the next procedure. Finally, the specimens were randomly divided into four equal groups, with each group consisting of 15 specimens. Group1: Control Group with unprepared canals, Group 2: K-file (Mani inc, Japan), Group3: MTwo (VDW, Munich, Germany), Group 4: K3XF (Sybronendo, Orange, CA).

Root Canal preparation was done as per the manufacturing instructions. After instrumentation, the canals were irrigated with normal saline and then rinsed with distilled water using a 2 ml disposable syringe and a 26-G needle (Unolock, Hindustan Syringes and Medical Devices Ltd). All specimens were stored in distilled water until the next procedure. Each specimen was sectioned horizontally at 3 mm and 6 mm from the root apex using a hard tissue microtome under water cooling (LEICA SP-1600, Wetzlar, Germany). The sections were examined for the presence of dentinal defects under a stereomicroscope (Magnus) at 45x magnification. Photographs of the sections were taken with a digital camera (Sony, 16.1 MP) attached to the stereomicroscope. Observations were categorized based on the presence or absence of dentinal defects at the 3 mm and 6 mm levels.

Based on the study of **Wilcox et al (1997)**[8], dentinal defects again classified into:

1. FRACTURE: A line extending from the root canal surface to the outer surface of the root.
2. PARTIAL CRACKS: Extending from the canal wall into dentin without reaching the outer surface of the root.
3. CRAZE LINE: A line extending from the outer surface of the root into the dentin that cannot reach the canal lumen. The data were collected and recorded for statistical analysis.

RESULTS

The incidence of various defects was analyzed using the Chi-Square test at a specified significance level (p). The findings were reported as the number and percentage of samples with or without defects in each group.

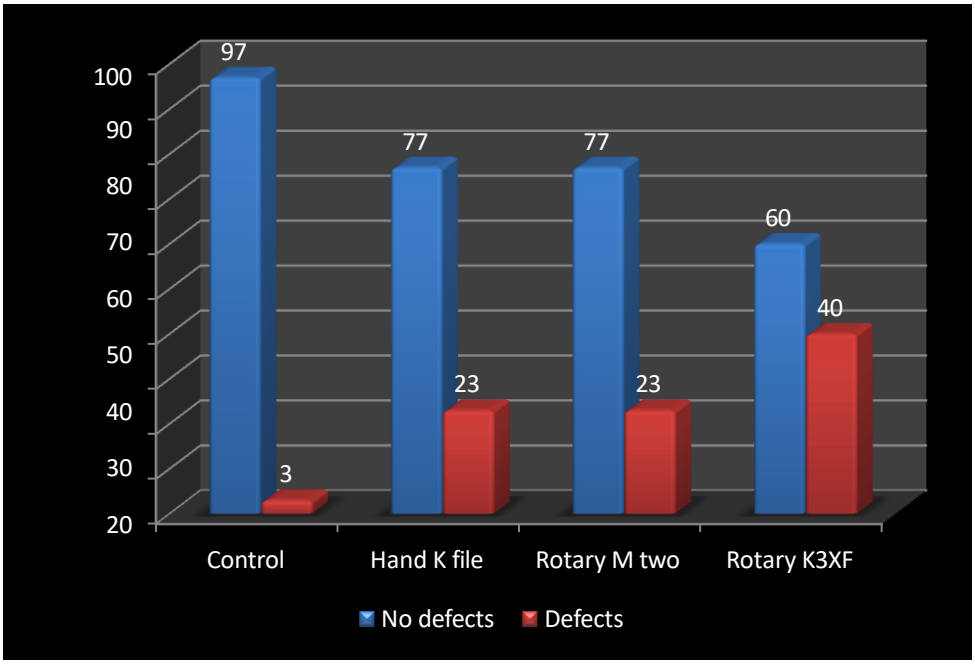
Inter-group comparison for defects: A statistically significant difference ($p < 0.05$) was observed when Groups 2, 3, and 4 were compared to Group 1.

Inter-group comparison for types of defects:
For fractures and partial cracks, the order was Group 2 < Group 3 < Group 4.
For craze line defects, the order was Group 1 < Group 3 < Group 4 < Group 2.

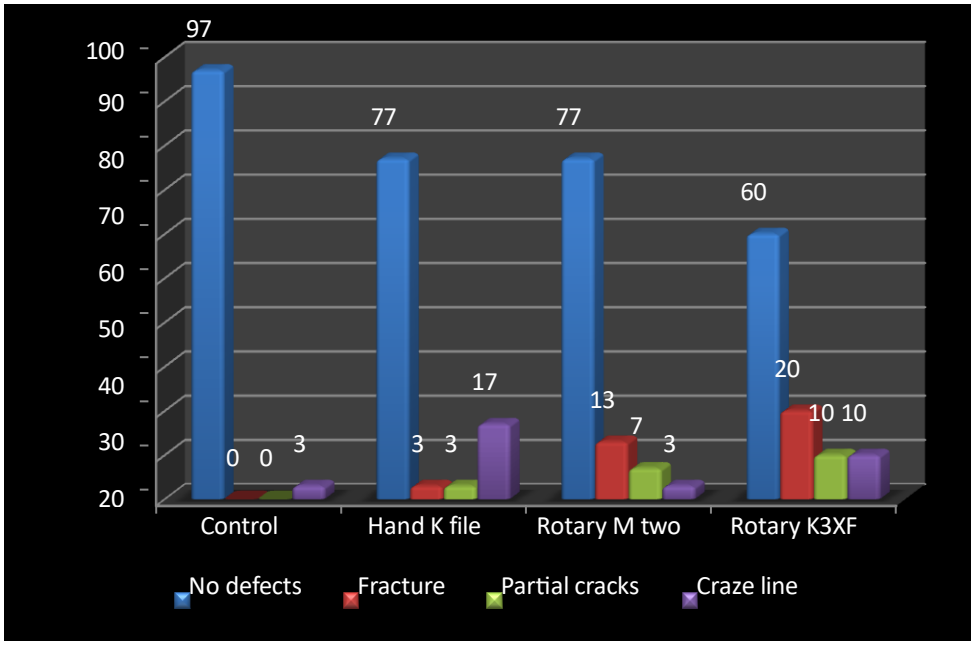
Intra-group comparison for types of defects:
Group 2 showed a higher number of craze lines compared to fractures and partial cracks.
Group 3 exhibited defects in the order of fractures > partial cracks > craze lines.
Group 4 had more fractures than partial cracks and craze lines.

Defect comparison at different depths: No statistical difference ($p > 0.05$) was observed when defects at 3 mm and 6 mm were compared.

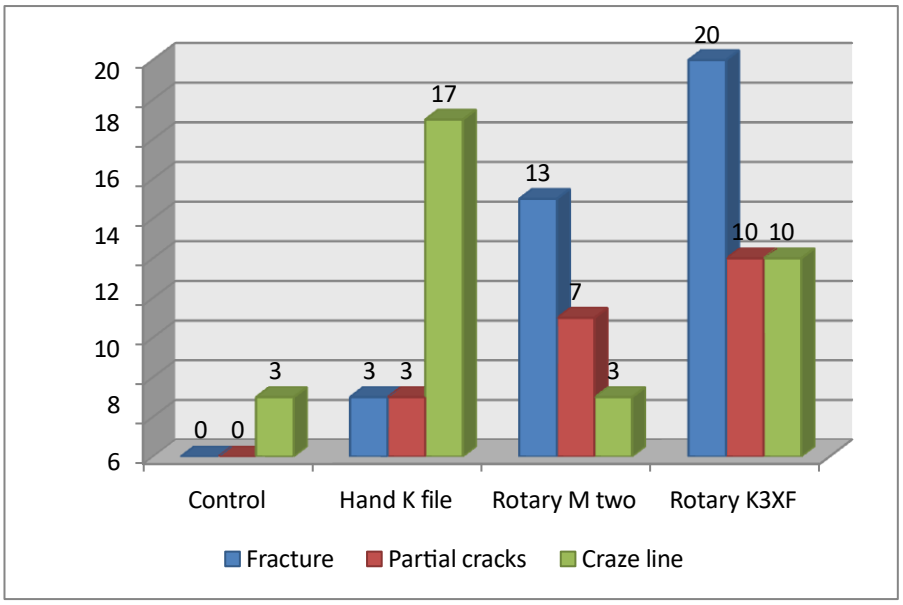
Overall defect analysis:
The total number of defects followed the order: Group 1 < Group 2 < Group 3 < Group 4.
For the types of defects, the order was: partial cracks < craze lines.



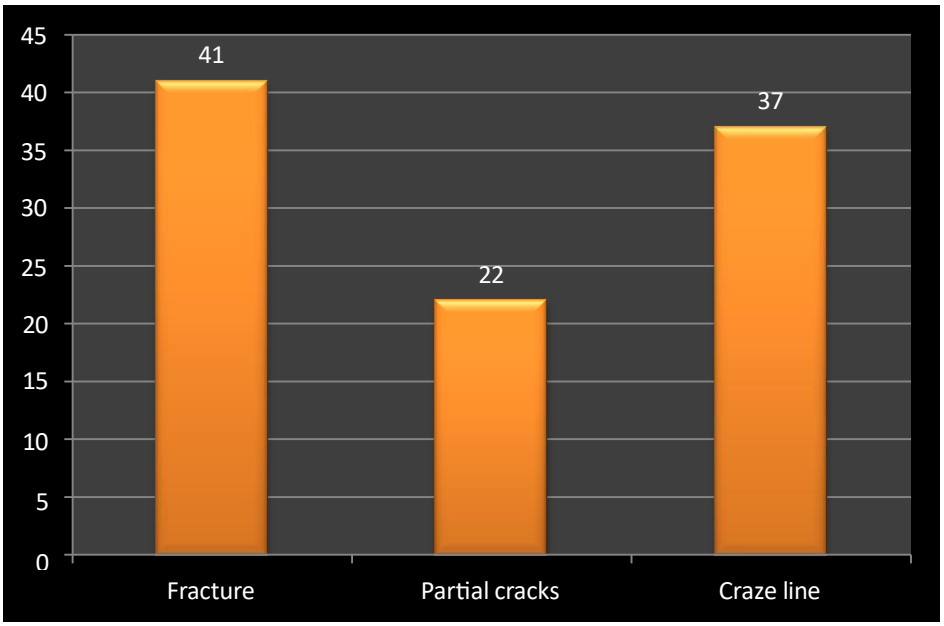
Graph 1: Percentage of No defects and Defects in each Group



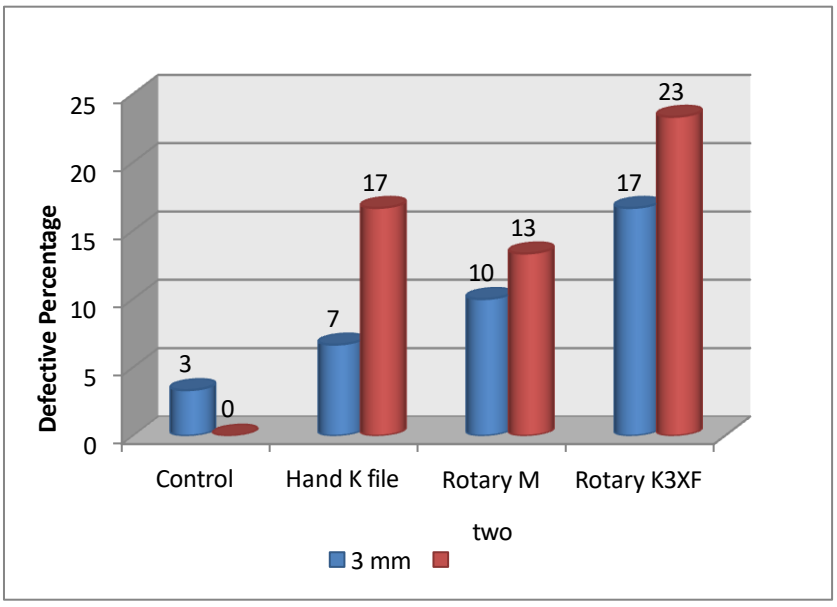
Graph 2: Comparison of No defects and Types of defects in each group



Graph 3: Comparison of Types of defects in each Group



Graph 4: Comparison of total percentage of Types of defects



Graph 5: Comparison of defects at 3mm and 6mm in between groups

DISCUSSION

Dr. Herbert Schilder outlined the principles of ideal root canal instrumentation, emphasizing that the preparation should:

1. Create a continuously tapering funnel from the coronal access to the root apex.
2. Preserve the original anatomy of the canal.
3. Maintain the apical foramen in its original position relative to the periapical tissues and root surface.
4. Keep the apical foramen as small as possible.

Vertical Root Fractures and Microcracks

Vertical root fractures are thought to result from the gradual weakening of the root structure, often beginning as microcracks. These microcracks may develop during root canal treatment or due to long-term occlusal stresses. Understanding the causes of microcracks is crucial for ensuring successful root canal treatment.[9-11]

Stress and Dentinal Defects during Preparation

Shaping the root canal involves contact between instruments and the dentinal walls, causing temporary stress concentrations in the dentin. These stress concentrations can result in dentinal defects, which may progress into fractures. Studies have reported a higher incidence of such defects when nickel-titanium (Ni-Ti) rotary files are used compared to hand instruments.[12-13]

Kim et al. (2010)[14] reported that the design of files influences stress and strain concentrations at the apical region during instrumentation, which are associated with an increased risk of dentinal defects. Similarly, **Yigit et al. (2015)**[15] observed that no defects occurred in unprepared canals, but all types of instruments caused dentinal defects. There were no significant differences between instrument systems, though significantly more defects were observed at the 3-mm level. They concluded that both hand and reciprocating instruments could contribute to dentinal defect formation during root canal preparation. Comparisons between rotary Ni-Ti instruments and stainless-steel hand instruments indicated that manual techniques with stainless-steel files provide comparable or superior cleaning efficiency while generating significantly less debris.

Vamsee Krishna et al. (2014)[16] investigated the incidence of dentinal damage during root canal preparation using three different Ni-Ti rotary systems (ProTaper Universal, Twisted Files, and Mtwo). They concluded that, regardless of the rotary system used, instruments with greater taper increased the likelihood of dentinal defects. In the present study, the Mtwo group exhibited fewer defects (23%) compared to the K3XF group (40%) and an equal number of defects to the hand K file group (23%). The Mtwo group recorded four fracture-type defects, whereas the hand file group had only one.

In this conducted in-vitro study, the hand file group exhibited fewer defects (23%) compared to the K3XF rotary Ni-Ti file group (40%) and an equal number of defects to the Mtwo group (23%). Regarding the types of defects, the percentage of teeth with fractures was 3% for the hand file group, 13% for the Mtwo group, and 20% for the K3XF group. Factors contributing to the reduced defects in the hand file group include its minimal taper design, enhanced tactile feedback, and precise manual control over dentin removal during preparation. A minimal taper of 2% induces significantly less strain on the dentinal walls.

CONCLUSION

Within the limitations of this in vitro study, it was concluded that hand K files caused the fewest dentinal defects, followed closely by rotary Mtwo files, which also induced fewer defects than rotary K3XF files. Among all groups, rotary K3XF files generated the highest number of dentinal defects. Fracture-type defects were observed more frequently with rotary files compared to hand K files, with rotary Mtwo files producing more fractures than hand K files but fewer than rotary K3XF files. Overall, fracture-type defects were predominantly associated with the use of rotary instruments.

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